

ates terrain traversability cost; detects low overhangs and high-density obstacles; and can perform geometry-based terrain classification (ground, ground cover, unknown).

A new origin is automatically selected for each single-frame terrain map in global coordinates such that it coincides with the corner of a world map cell. That way, single-frame terrain maps correctly line up with the world map, facilitating the merging of map data into the world map. Instead of using 32 bits to store the floating-point elevation for a map cell, the vehicle elevation is assigned to the map origin elevation and reports the change in elevation (from the origin elevation) in terms of the number of discrete steps. The single-frame terrain map elevation resolution is 2 cm. At that resolution, terrain elevation from -20.5 to 20.5 m (with respect to the vehicle's elevation) is encoded into 11 bits.

For each four-byte map cell, bits are assigned to encode elevation, terrain roughness, terrain classification, object classification, terrain traversability cost, and a confidence value. The vehicle's current position and orientation, the map origin, and the map cell resolution are all included in a header for each map. The map is compressed into a vector prior to delivery to another system.

*This work was done by Arturo L. Rankin of Caltech for NASA's Jet Propulsion Laboratory. Further information is contained in a TSP (see page 1).*

*This software is available for commercial licensing. Please contact Daniel Broderick of the California Institute of Technology at danielb@caltech.edu. Refer to NPO-47039.*

## Auto Draw From Excel Input Files

The design process often involves the use of Excel files during project development. To facilitate communications of the information in the Excel files, drawings are often generated. During the design process, the Excel files are updated often to reflect new input. The problem is that the drawings often lag the updates, often leading to confusion of the current state of the design.

The use of this program allows visualization of complex data in a format that is more easily understandable than pages of numbers. Because the graphical output can be updated automatically, the manual labor of diagram drawing can be eliminated. The more frequent update of system diagrams can reduce confusion and reduce errors and is likely

to uncover symmetric problems earlier in the design cycle, thus reducing rework and redesign.

*This work was done by Karl F. Strauss, Renaud Goullioud, Brian Cox, and James M. Grimes of Caltech for NASA's Jet Propulsion Laboratory. For more information, contact iaoffice@jpl.nasa.gov.*

*This software is available for commercial licensing. Please contact Daniel Broderick of the California Institute of Technology at danielb@caltech.edu. Refer to NPO-46926.*

## Observation Scheduling System

Software has been designed to schedule remote sensing with the Earth Observing One spacecraft. The software attempts to satisfy as many observation requests as possible considering each against spacecraft operation constraints such as data volume, thermal, pointing maneuvers, and others. More complex constraints such as temperature are approximated to enable efficient reasoning while keeping the spacecraft within safe limits. Other constraints are checked using an external software library. For example, an attitude control library is used to determine the feasibility of maneuvering between pairs of observations. This innovation can deal with a wide range of spacecraft constraints and solve large scale scheduling problems like hundreds of observations and thousands of combinations of observation sequences.

*This work was done by Steve A. Chien, Daniel Q. Tran, Gregg R. Rabideau, and Steven R. Schaffer of Caltech for NASA's Jet Propulsion Laboratory. For more information, contact iaoffice@jpl.nasa.gov.*

*This software is available for commercial licensing. Please contact Daniel Broderick of the California Institute of Technology at danielb@caltech.edu. Refer to NPO-47189.*

## CFDP for Interplanetary Overlay Network

The CCSDS (Consultative Committee for Space Data Systems) File Delivery Protocol for Interplanetary Overlay Network (CFDP-ION) is an implementation of CFDP that uses ION's DTN (delay tolerant networking) implementation as its UT (unit-data transfer) layer. Because the DTN protocols effect automatic, reliable transmission via multiple relays, CFDP-ION need only satisfy the requirements for Class 1 ("unacknowledged") CFDP. This keeps the implementation small, but without loss of capability.

This innovation minimizes processing resources by using zero-copy objects for file data transmission. It runs without modification in VxWorks, Linux, Solaris, and OS/X. As such, this innovation can be used without modification in both flight and ground systems. Integration with DTN enables the CFDP implementation itself to be very simple; therefore, very small. Use of ION infrastructure minimizes consumption of storage and processing resources while maximizing safety.

*This work was done by Scott C. Burleigh of Caltech for NASA's Jet Propulsion Laboratory. Further information is contained in a TSP (see page 1).*

*The software used in this innovation is available for commercial licensing. Please contact Daniel Broderick of the California Institute of Technology at danielb@caltech.edu. Refer to NPO-47084.*

## X-Windows Widget for Image Display

XvicImage is a high-performance X-Windows (Motif-compliant) user interface widget for displaying images. It handles all aspects of low-level image display. The fully Motif-compliant image display widget handles the following tasks:

- Image display, including dithering as needed
- Zoom
- Pan
- Stretch (contrast enhancement, via lookup table)
- Display of single-band or color data
- Display of non-byte data (ints, floats)
- Pseudocolor display
- Full overlay support (drawing graphics on image)
- Mouse-based panning
- Cursor handling, shaping, and planting (disconnecting cursor from mouse)
- Support for all user interaction events (passed to application)
- Background loading and display of images (doesn't freeze the GUI)
- Tiling of images.

It does not read images directly, so it can work with any image file format. It is the application's responsibility to read the image and supply it to XvicImage. The xvd and tp programs (part of the VICAR image processing package) are dependent on XvicImage for their operation.

*This work was done by Robert G. Deen of Caltech for NASA's Jet Propulsion Laboratory. For more information, contact iaoffice@jpl.nasa.gov.*

*This software is available for commercial licensing. Please contact Daniel Broderick of the California Institute of Technology at danielb@caltech.edu. Refer to NPO-46922.*